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SOME CASES OF TRANSPLANTATION AFTER ORELL'S METHOD

In his dissertation "Studien über Knochenimplantation und Knochenneubildung, Implantation von os purum sowie Transplantation von os novum" (1934) Svante Orell published a good many studies on and experiments with a new method for transplantation given by him.

In order to be able to study more thoroughly the building of bone in the Albee operation for spondylitis, Orell implanted various different transplants in the cavities left by removal of sections of the tibia—partly fragments of the bone removed (*i.e.*, autoplasmic material), partly heteroplasmic material (*i.e.*, pieces of bone, freed from fat, connective tissue and protein material), which substance Orell designated as "*os purum*".

The new complicated and time-consuming method for the preparation of this bone consists essentially in dissolving of the blood albumin through soaking in a solution of sodium chloride, disintegration of the connective tissue in hot potassium hydroxide and removal of the fat through soaking in acetone. Only in this way has it been possible to obtain the bony trabeculae perfectly clean and suitable for ingrowth of the osseous connective tissue.¹⁾

After some length of time, shorter or longer, Orell removed these fragments of os purum and was able on microscopic exa-

¹⁾ A.B. Pharmacia, Stockholm, has undertaken the preparation of such *os purum*, which is now obtainable in the market in all sorts of forms, both as compact bone and as spongy bone.

mination to study the histological features in this form of bone healing.

Orell was able thus to ascertain the following facts: If the os purum is implanted directly in the resection cavity, the implant will gradually undergo complete absorption. When the os purum is implanted subperiosteally on the tibia there will be a plentiful production of new-formed bone in the cracks between the implant, the tibia and the periosteum. In this way Orell arrived at the idea first to make a subperiosteal bridge of os purum (on the tibia), and 1—2 months later excise this bridge together with the surrounding new-formed bone, which he called *os novum*. Then this os novum and os purum was transplanted to the site of the intended osteosynthesis, so that the new site of transplantation is provided from the very start with young bone-forming cells. The os purum serves as a support of the new bone, and its shape is a decisive factor in the form of the new bone. In about 300 days there is established an arcade between the bridge and the loss of substance from resection; and the os novum makes up the essential part of this bridge. The os novum consists in connective tissue and osteoid tissue, formed from the superficial Haversian canals in the tibia and from the inner layers of the periosteum, elevated by the bridge of os purum.

Orell has further shown that the osseous connective tissue in the os novum chiefly consists in canalicular connective tissue, and that the bone production in the os novum appears to be more lively than in fresh autoplasmic bone transplants. Owing to its softness, the os novum can adjust itself and fit in better in the new bedding, and it agrees better with the soft tissue elements than does full-fledged fresh bone. Nor is poorly, thin or scarry skin—for instance, over an pseudarthrosis—irritated to the same degree by this new bone as by hard bone. With a view to the bone production, then, it would be of greater advantage to use os novum in the transplantation instead of fully developed fresh bone.

Orell has used os purum alone as transplanting material in a large number of cases to cover defects or replace foci removed

by curettage, or for the mutual fixation of bony elements (fractures, pseudoarthrosis). If the overlying skin has not been injured and if the morbid osseous process (*e.g.* tuberculosis of bone) has been in a quiescent state, as a rule the transplant has healed in and become organized without any complication. Orell has been able to demonstrate clinically that when os purum is implanted in extrasketal connective tissue—for example, subcutaneous tissue—the bone formation does not begin until three months after the implantation, and even then it proceeds very slowly. In order to make the new bone permanent, it further requires exposure to physiological skeletal strain. If this condition is not met, the bone undergoes complete absorption. If now os purum is again implanted in the skeleton—that is, in a milieu containing osseous connective tissue—the osseous tissue begins to proliferate and form new bone as early as two weeks after the implantation. The complete absorption of the os purum and its replacement by new bone proceeds very slowly (2—3 years).

Whether these most interesting studies and operations in experimental surgery may have also some practical significance to surgical orthopedics is still an open question.

As I have had the opportunity even at a very early stage to follow Orell's investigations and methodical experiments from step to step, I have gained confidence in his work and its practical results, and as early as in the autumn 1934 I began to try out his methods practically.

My material comprises altogether 41 cases distributed as shown in Tables 1 and 2. As far as my cases are concerned the results of this operative method have been favourable. So it will be appropriate, I think, briefly to describe the procedure adopted in the various cases.

As to cases of spondylitis, as a rule I have introduced the treatment with gradual correction of the gibbus in plaster cast after Henning Waldenström's method. The development of the spondylitis has been followed through roentgenography every 3 months. The time for the operation has not been considered until all the signs have appeared to indicate a standstill of the

TABLE 1.
Implantation of os purum + Transplantation of os novum.

Diagnosis	No. of cases	Sex		Age		Observation period, maximum	Method of operation
		M.	F.	Max.	Min.		
Spondylitis, tuberculous ...	17	10	7	6	28	2 years and 9 months	Albee
Spondylithesis	1		1		35	9 months	Albee
Tuberculosis of the hip ...	7	7		12	17	2 years and 1 month	Extra-articular arthrodesis
Tuberculosis of the sacro-iliac joint	5		5	17	35	1 year and 2 months	Evacuation of foci + plugging
Pseudarthrosis	3	3		27	50	2 years and 6 months	Pseudarthrosis operation

TABLE 2.
Implantation of os purum.

Diagnosis	No. of cases	Sex		Age		Observation period, maximum	Method of operation
		M.	F.	Max.	Min.		
Tbc. of the foot	3		3	15	23	1 year and 1 month	Partial and total resection + filling
Tbc. of the knee	3	2	1	18	26	2 years	Resection of the knee-joint
Tbc. of the shoulder-joint	1		1		20	4 months	Resection
Arthritis deformans of the knee	1		1		51	1 year	Resection of the knee-joint

In addition, a number of cases in which os purum has been used as fixation material in osteoplasty, operative fixation of fractures, osteotomy, etc.

process, a normal calcium content of the remnants of the vertebrae, quiescent features of the shadow of the abscess, etc.

Seance 1 consists in implantation of a bridge of os purum under the periosteum of the tibia; and this is always done under local anaesthesia. It is easy to carry out even on children. The youngest patient I have performed this operation on was 6 years.

It is quite important to use a suitable splinter of os purum for this implantation. For the Albee operation only long and narrow strips are suitable. Furthermore, it has been found to be of advantage to the production of os novum if one of the long surfaces of the splinter is rough and more spongiose. After boiling for 10 minutes in salt solution, as directed, also these bridges become more soft, so that they may be bent as wanted. It also seems to be rather important to push the bridge well in under the periosteum so that no part of the os purum projects into the crevice, which will always appear when the tensely stretched periosteum is sutured. The skin is sutured with a running suture. In order to counteract the hæmatoma, which otherwise appears as a rule, I have lately placed a small piece of rubber tubing at the edge of the wound, with removal of this drain on the day after the operation. The bandage of the wound is always covered by an elastic bandage that is applied also to the foot. Notwithstanding these measures, a small hæmatoma has been unavoidable in several cases; but it has always been easy to evacuate, and it does not seem to have impeded the implantation of the bridge or the production of os novum. In the first 24 hours, naturally the patient is troubled by pain arising from the increased tension of the periosteum, but this inconvenience seems to be quite minimal even on the next day. The suturing stitches are removed after 8—12 days, and then the patient is allowed to move his leg freely. It seems even to be a great therapeutic advantage if the leg is not kept all too still.

Seance 2. Osteosynthesis + transplantation of the os purum and os novum ought to be carried out from 6 to 9 weeks after the preliminary implantation of the os novum, depending upon the age of the patient. The younger the patient, the more rapidly

proceeds the formation of os novum. If, for instance, in a patient, 10 years old, the interval between the two seances is longer than two months, the splinter of os purum has become embedded so firmly and solidly that it may be difficult even with a chisel to get into the proper position between splinter and bed.

I have used universal anæsthesia only when the patients have been under 12 years of age or very restless; in all other cases I have worked under local anæsthesia, which is very satisfactory. I always begin the operation with a "Thürflügel" incision over the spinous processes of the vertebræ that are to be fixated. Then I split the spinous processes in the usual manner, taking care to get the spongiose bony cut-surfaces so large as possible. Then the skin and soft parts of the leg along the old scar are divided with one incision, going directly into the periosteum. This structure which now is found to be thickened considerably and cicatricial is turned to the side by means of a raspatorium; after this, there usually is no particular difficulty in loosening the os purum bridge and os novum in one piece. But even if the connection between the os purum and the os novum is loosened, it appears not to make any difference whatever if then the os purum and the os novum are transplanted to the site of grafting separately. Naturally it is of some importance to place that side of the transplant that had been resting against the surface of the tibia so it gets in direct contact with the denuded spongy surface of the articular processes of the vertebræ. If the os purum splinter appears to have become too brittle from atrophy to be serviceable as a "stabilizing frame" one may instead very well put in a perfectly fresh splinter of os purum besides the os novum. It often happens that the form of the primary bridge of os purum has not fitted well as a transplant, or that it may be preferable to use a longer or more rough splinter. (On an average, this operation takes about 45 minutes.)

After the completion of this operation the patient is again put in plaster; and this cast should be padded well in order to avoid pressure. As a rule, the skin stitches are not removed

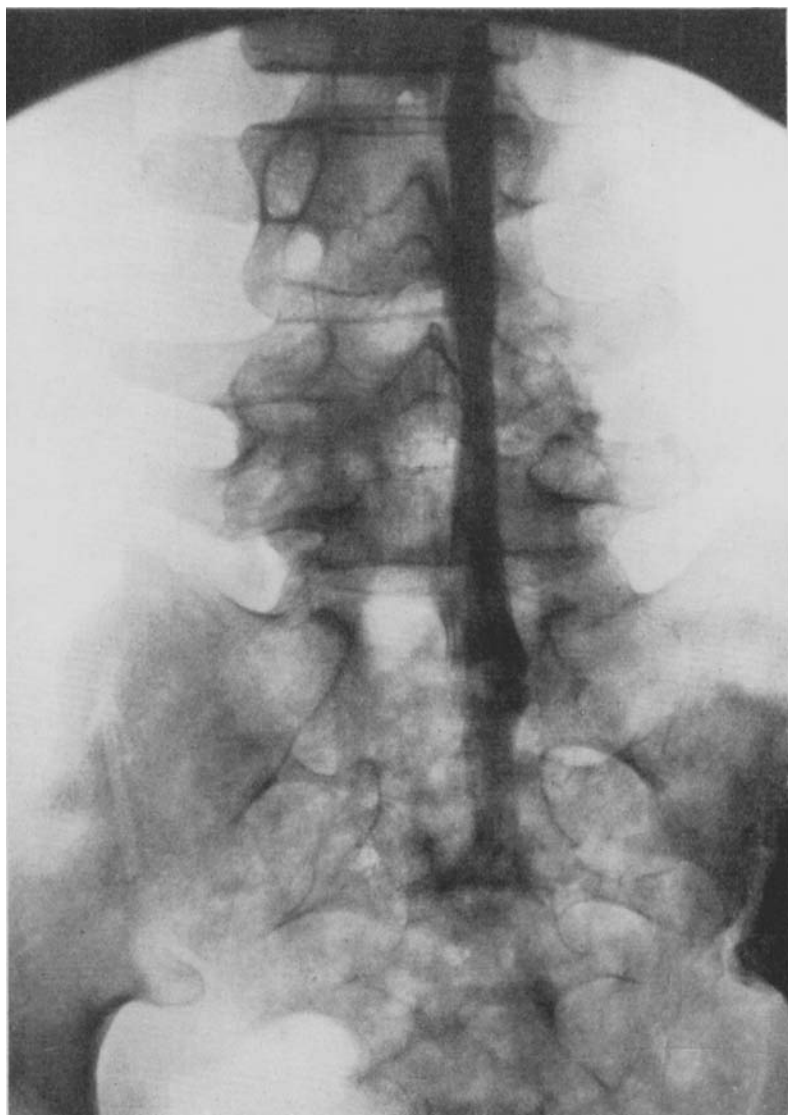


Fig. 1.

Case 1. Vertebrae (frontal picture), 16 months after the operation.

until 10—14 days after the operation, when the muscular cramps, usually insignificant, have ceased completely.

In all my cases of spondylitis the operative wound has healed by first intention. An insignificant sequestration of the os purum splinter was observed in two cases. On the other hand, there has been no instance of hæmatoma or serous discharge from the wound, which seems to be a common phenomenon in arthrodesis operation on the hip-joint (see below) or in cases

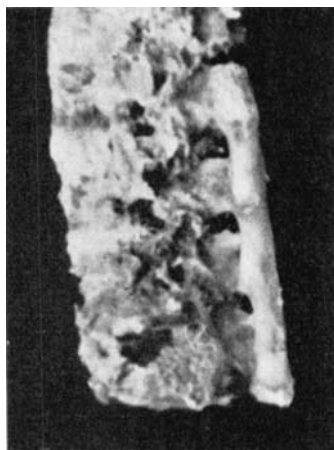


Fig. 2.
Vertebræ (autopsy specimen).

where a large amount of os purum spongiosum has been employed.

Not before 9 weeks after the operation does the patient begin to get up a little, still in plaster cast. Of course, older patients have been confined to bed for a longer time. As a rule, Orell has not allowed his patients to get up before 4 months after the osteosynthesis. I have not seen any inconvenience from letting the patients get up sooner, within the limits mentioned above. The after-treatment, as far as the type of corset and such things are concerned, has not differed from the procedure given by Waldenström. The improvement has kept progressing normally in all the cases excepting one (Case 1).

Subsequently, amyloidosis, with which disease the patient died on July 23, 1937.

In spite of the very poor general condition of this patient in the last two years, the healing of the bone and the formation of an arch between the spinous processes were progressing vigorously as is plainly evident from Figs. 1—3.

Case 2. A. N., male, 10 years old. Tuberculous spondylitis involving the thoracic vertebræ VI—XII inclusive. Large gibbus. Pareses of the lower extremities. These pareses disappeared after treatment with plaster cast for some length of time. On August 13, 1935: Subperiosteal implantation of os purum. On October 15, 1935: Albee-Orell operation. In this case the os purum bridge was curved and long, in order to obtain a better adjustment of the large gibbus. Thanks to a particularly plentiful production of os novum, the healing of the bone has been very good.

Encouraged by the results obtained already in cases of spondylitis, I have since gone on to employ this transplantation method also in several other cases.

In order to promote the natural and desirable ankylosis formation in *tuberculosis of the hip*, in the last 15 years especially American and French orthopedists have worked out different operative methods for the purpose of arthrodesis. The intra-articular arthrodesis, which may be compared to resection of the knee-joint, has been employed in particular by French surgeons—*e.g.*, Tavernier, Lerich, Sorrel. The results have not been very encouraging, however, and hence orthopedists have nearly all gone on to employ the *extra-articular arthrodesis*, aimed at absolute fixation between the trochanter and the ilium. Now distinction is made between para-articular and juxta-articular arthrodeses. The latter is particularly serviceable in cases of strong upward displacement of the trochanter, as thus the trochanter is used as the transplant by forcing it upwards. When the distance between the iliac crest and the trochanter is wide the para-articular arthrodesis is the more serviceable.

In this instance, of course, we have to take the transplant from somewhere else.

In 7 cases of tuberculosis of the hip, treated after this



Fig. 4.

Case 2. Thoracic vertebræ (side view), 1 year and 10 days after the operation.

method, I have used a transplant of os purum and os novum, in the following way:

Seance 1.—The implantation of the os purum was performed in the same way as in the cases of spondylitis. As a rule, the morbid process in the hip in these patients has gone so far that the patients have been walking about in plaster cast. For the inoculation of the os purum splinter, which here ought to be a little more coarse and longer, the patient should be confined to bed at the most for 8—10 days. Then he is allowed to get up again and walk about, and this seems even to promote the production of os novum.

Seance 2 may be carried out under local anaesthesia, even to some advantage. The skin incision is laid from a few centimetres back of the spine to the base of the trochanter. After incision into the muscular fascia, the greater trochanter is divided longitudinally from its base to the tip, and the fissure is widened gradually without producing any fracture. Then a segment of the ilium is chiseled out, measuring about 2×3 cm., about 3—4 cm. below the iliac crest, all depending on the individual case. Here, too, one should be very careful not to fracture the segment in lifting it up. It is most desirable if it is springy. Instead of dividing the musculature in its entire length between the trochanter and the os ilium, I make my way bluntly from above and downwards, beneath and in the muscular layer, and in this way I obtain a tunnel, in which subsequently the transplant of os purum and os novum (removed in the usual way) is pushed in and fixed. Usually the transplant is fixed sufficiently through the generally strong tension between the divided fragments and the trochanter. A few times it has been necessary to drive in a small spike of os purum in the upper end of the transplant. I have been particularly gentle in handling the valuable loop of os novum which as a rule has to be pushed into the "tunnel" after the os purum bridge has been fixed. The fascia is sutured with catgut, the skin with a running suture. Usually the whole operation takes no more than about 40 minutes. Then the patient is put in plaster (hip cast), with an opening for the operation wound. I let the patient get up after 3 months, and as a rule there is no trouble on that account. But the patient is not allowed to stand on his foot until 6

months after the operation. Then, gradually, the plaster cast is replaced by a non-articulated hip-strap of leather.

This leather bandage is not to be left off until about 2 years after the operation, as a general rule. Of course, in cases where the establishment of the ankylosis has proceeded rather rapidly, with vigorous production of new bone, the patient may be allowed to walk about without bandage at an earlier point of time.

With regard to the healing of the operation wound, as pointed out already, in these cases I have not obtained complete healing by first intention—contrary to the findings in the spondylitic cases. As a rule, a hæmatoma is formed, followed by a discharge of serous and bloody fluid that may keep on for up to 3 weeks. After this, the healing has progressed normally except in 2 cases.

In one of these cases the os purum bridge had loosened from the trochanter, either because I had not been able to fix its distal end properly, or because the wedging of the trochanter had been incomplete. So, two months after the operation the os purum bridge had to be extracted. In the meantime the os novum had healed in firmly, and on roentgenography it appeared to keep promoting further production of bone. It is too early yet to say anything as to whether this process will result in a really solid bone bridge. In the other case the serous discharge from the wound stopped after removal of a sequestrum (about 2 cm. in length) from the bridge.

The usual employment of an autotransplant taken from the tibia does not fully ensure that the solidity of the transplantation is great enough alone to stand the strain upon the joint before complete ankylosis is established. And the same applies to this operation with a transplant of os purum and os novum as outlined above. Naturally, however, the "inner corset" effectuated by the bony connection between the trochanter and the ilium will contribute to promote the healing of the tuberculous process in the hip and thus promote too the desired ankylosis.

In a couple of cases the subsequent roentgenograms have

shown the presence of a "fracture" of the bridge. It might, I think, be very doubtful whether any true fracture is involved in this process. It is true that the healing of this transplantation includes also a callus formation, but I am inclined to think that the "callus" here consists in areas of infiltration for absorption of the os purum. Once the production of new bone is established the fragment-like elements undergo fairly rapid absorption.



Fig. 5.

Case 3. Roentgenogram of the left hip-joint, 5 months and 3 days after the operation.

Case 3. J. K., male, 15 years old. Tuberculosis of the left hip. On November 28, 1935: Subperiosteal implantation of os purum on the tibia. On February 3, 1936: Extra-articular arthro-



Fig. 6.

Case 3. Roentgenogram of the left hip-joint—1 year, 3 months and 7 days after the operation.

desis on the left hip-joint, with transplantation of the os purum and os novum. Hip-plaster with fenestra for the wound. February 18, 1936: Secretion from the wound has ceased completely. July 6, 1936: New fracture of the bridge about 2 cm.



Fig. 7.

Case 4. Roentgenogram of the right hip-joint—1 year, 1 month and 18 days after the operation.

above the previous fractures, which now show vigorous callus formation. October 10, 1936: The patient is allowed to get up, with hip-plaster. May 10, 1937: All the "fractures" healed well. Leather bandage. July 22, 1937: Patient discharged, feeling well.

Case 4. A. A., male, 10 years old. Tuberculosis of the right hip. On October 22, 1935: Subperiosteal implantation of os purum on the tibia. On December 28, 1935: Extra-articular arthrodesis, with transplantation of the os purum and os novum. Hip-plaster with fenestra for the wound. January 15, 1936: Wound healed by first intention, after slight serous secretion for a few days. March 18, 1936: The patient is allowed to get up. April 20, 1936: Hip-plaster replaced by non-articulated hip-strap. Bone bridge healed in well. September 2, 1936: Patient discharged, improved.

Even in operation on patients suffering from *tuberculosis of the sacro-iliac joint* I have found this method for transplantation to be of advantage. My patients in this group have all been women, the youngest 17 years old, the oldest 35.

Seance 1: Subperiosteal implantation of os purum on the tibia, in the same manner as described above.

Seance 2. Even in most cases of this kind it is possible to perform the operation under local anæsthesia. Only when the condition involves large abscesses, is it advisable for technical reasons to employ universal anæsthesia or lumbar anæsthesia.

The greatest difficulty is rapidly to locate the tuberculous focus. Even though the roentgenogram shows distinct changes, and a small piece of lead has been pasted on the skin for indicator, it may often be very hard to locate the focus. In my cases the process has always been found in the distal part of the joint. If an abscess is encountered, it usually is easy to find the bony focus. Now, it is particularly important that this focus be scraped out so completely as possible, and that all tuberculous granulation tissue be removed. The "hole" is then washed with carbolic acid and alcohol.—As this scraping and chiseling often leaves a rather extensive defect in the osseous tissue, I have plugged the whole cavity with os purum spongiosum. For this I use a club-shaped wooden stick, of oak, of special construction. It is important to pack the os purum fragments firmly, effectuating in this way at the same time a good stopping of the hæmorrhage.

The periosteum of the surrounding normal bone is lifted up,

and then the transplant of os purum and os novum is transferred as usually from the tibia to the joint involved. The plugged focus is now covered with the transplant, which thus lies like a bony bridge from the normal surface of the ilium to the sacrum. Then the overlying periosteum and soft parts are sutured with catgut, the skin with a running suture.

In 4 of these cases the primary healing did not take place for a few weeks, owing to an insignificant serous discharge. After confinement to bed for $2\frac{1}{2}$ months in plaster cast I have let the patients get up, wearing a cloth corset. As early as 6 months after the operation, 3 of these patients were fully able to work and entirely free from the sciatica-like pains they had been troubled with before. In one case the healing was delayed by an abscess in the soft parts, followed by a rather persistent secretion. Now, 5 months after the operation, the wound has healed completely. But the patient has not been discharged yet on account of slight but persistent symptoms of rheumatism. The sedimentation rate of the red blood cells is somewhat increased. Roentgenography shows no sign of relapse or any new focus.

In the treatment of *pseudarthrosis*, I think, this method of transplantation may get to play a great rôle. In the three cases in which I have used the method the results have been extraordinarily favourable.

The os novum is a suitable material for filling up the defect between the fragments, and it seems at the same time to have a very stimulating effect on the bone production. It seems to be an advantage too, as illustrated by Case 5, that it is not necessary to open the entire pseudarthrosis in order to obtain a good consolidation.

Case 5. T. K., male, 27 years old. On November 1, 1934: *Complicated fracture of the right leg.* After hospitalization for 3 months, the patient returned home, with the leg in plaster. On June 8, 1936: Still signs of pseudarthrosis. Pain on walking without a supporting bandage. Marked curvature of the leg. June 9, 1936: Subperiosteal implantation of os purum on the tibia. June 19, 1936: The sutures are removed; and the patient

is discharged, to return later for further treatment. On August 20, 1936: Readmitted to the hospital. August 21, 1936: Operation, under local anæsthesia. The anterior surface of the tibia is smoothed, and 2 longitudinal grooves are chiseled out on both



Fig. 8 & Fig. 9.

Case 5. Roentgenograms of the right leg (side view) before and after the pseudarthrosis operation (respectively June 8, 1936, and February 15, 1937).

sides of the pseudarthrosis. The bone transplants are placed in these grooves and covered with periosteum and soft tissues. After suturing, plaster bandage. August 30, 1936: Sutures removed; primary healing of the wound. October 12, 1936: Walk-

ing plaster cast. February 15, 1937: The patient is walking about without plaster cast, and free from pain. The pseudarthrosis has healed clinically.

In resection of the ankle-joint and knee-joint, employment of the os purum may be exceedingly valuable for the purpose of fixation as well as to fill in the curetted foci. Thus it is not necessary to resect so deeply, and in this way one avoids the shortening which otherwise is practically unavoidable.

Only in a couple of cases is it reasonable to assume that this implantation has delayed the course of healing. There has been no sequestration in any of these cases. When the tuberculous processes are more limited it is possible after this method to limit the operation to a partial resection, as shown in Case 6.

Case 6. I. A., female, 23 years old. Tuberculosis of the right foot. Since the beginning of 1935, pain in the right foot. On April 14, 1936, a tuberculous process was ascertained in the joint between the navicular and the cuneiform bones. May 12, 1936: Operation, consisting in partial resection. The joint was opened, and after removal of the capsule, articular cartilage, and granulation tissue, the navicular and all three cuneiform bones were peeled with chisel until solid bone was reached. In this bony hole, measuring 4 cm. in length and 1.5 cm. in width, two wedges of os purum were put in, and the covering soft structures were sutured with catgut, the skin with running suture. The foot in plaster cast, with fenestra for the wound. May 25, 1936: Slight necrosis in one skin edge of the wound; very slight serous discharge. July 11, 1936: The wound is healed. August 12, 1936: Walking plaster cast. January 10, 1937: Non-articulated leather capsule for the foot. May 12, 1937: Roentgenography shows commencing reconstruction of the implanted material.—Good movements in the ankle-joint. No pain on walking; insignificant limping.

According to my experiences so far this method for transplantation implies a good many advantages for our practical work in orthopedic surgery.

Apart from the drawback, that by requirements of os novum



a

*Fig. 10.*

Case 6. Roentgenogram of: a) left foot; b) right foot.

the operation is carried out in two seances, this new method for transplantation offers the following advantages:

1) that the operations are relatively simple and easy to perform;

2) that in most cases the operations required may be carried out within a relatively short time and under local anæsthesia;



Fig. 11.

Case 6. Roentgenogram of the right foot 1 year after the operation.

3) that in the treatment of spondylitis the Albee operation may be carried out even on children, to whom the resection of a large transplant from the tibia may imply a good deal of discomfort and even the risk of a fracture;

4) that the transplantation material is more plastic and more easily adjustable;

5) that the obtained solidity and the time required for the healing appear to be about the same as when the usual autoplasmic transplantation is employed;

6) that the os purum spongiosum is an exceedingly valuable material for filling and covering of defects and for the prevention of otherwise unavoidable shortening from resection;

7) that pseudarthrosis operations may be simplified, and that the os novum here appears to be of great significance to the bone production;

8) that spikes or splints, etc., of os purum constitute an excellent material for fixation of the bony parts, *e.g.*, in fractures, osteotomy, etc.

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